HABITAT CONDITIONS

Aquatic Community Classification

The majority of the basin lies within the Ozark faunal region (Pflieger 1997). This region is essentially an elevated plain that was uplifted near the beginning of the Pleistocene ice age. It has since been eroded by the streams that drain it. Limestone laid down by an ancient sea underlies most of the region. The limestone contains large quantities of chert that remain as coarse, angular rock fragments when the surrounding limestone dissolves away. The thin, stony soil derived from limestone does not favor intense crop production. Instead, large areas of the region are forested or devoted to pasture. The time span over which the region evolved created very physiographically diverse habitats.

Many streams of the basin occupy narrow, steep-sided valleys, and in places are bordered by sheer limestone bluffs. Streams typically consist of a series of short pools and well-defined riffles. Chert gravel washed down from the surrounding slopes is the most abundant streambed type. Cobble, boulders, and bedrock are also fairly common. The streams found in the basin are some of the clearest in the state. Most of the water that enters them is first filtered through unconsolidated deposits of chert. The basin also has a number of springs which contribute additional clear water to the streams and rivers into which they empty (Pflieger 1997).

Approximately 30 miles of the Lower Osage River are included in the big-river faunal region (Pflieger 1997). This region supports a distinct aquatic species assemblage which sets it apart from the Ozark faunal region. In its original condition, the rivers of the big-river faunal region occupied relatively wide braided channels with many islands and backwaters. Since European settlement, these areas have been subject to channel modification in an attempt to better facilitate river navigation. These modifications have increased velocities in the center of most channels and reduced the number of backwaters.

Several types of aquatic plants occur in the basin. Water cress (*Nasturtium sp.*) is often found near springs. Water willow (*Justicia sp.*) often occurs in riffle areas and along rocky shores and gravel bars. Other plants that are common along rocky areas are spatterdock or yellow pond lily (*Nuphar sp.*). Plants that prefer backwater areas include: coontail (*Ceratophyllum sp.*), water milfoil (*Myriophyllum sp.*), spatterdock or yellow pond lily (*Nuphar sp.*), and pond weeds (*Potamogeton sp.*).

Disturbances Caused by Land Use

Disturbances associated with logging, land clearing, burning, and overgrazing affected stream habitats of the basin and their fish faunas in the late 1800s and the early 1900s, though these changes went largely undocumented. These disturbances increased the bedload of gravel and finer sediments carried by the streams, resulting in higher turbidity, channel instability, and the filling of stream pools and backwaters (Pflieger 1997).

Channel Alterations and Their Effects on Habitat

In most streams and rivers, habitat quality is strongly linked to the stability of channel beds and banks. Unstable streams are less inhabitable to many aquatic species. Factors that increase or decrease sediment supply often destabilize streambeds and banks and result in dramatic channel readjustments (Roell 1999). Since unconsolidated chert is unstable, any disturbance of either a stream basin or its channel may cause accelerated movement of bedload during floods. This moving material tends to fill pools and cover rubble substrates which reduces the both the quantity and quality of fish habitat.

Channelization and Navigational Structures

In upper stream reaches, channelization has been small scale and widely scattered throughout the basin. The effects of these small scale channelization projects can have significant negative localized effects. Channelization increases the slope of the stream which leads to increase stream velocities and increased streambed erosion. Headcuts and bank scour are other negative effects of channelization. Overall the smaller order streams in the uplands of the basin are in relatively good condition and the majority of these streams have not undergone channelization.

On the Osage River, navigational structures have historically changed the shape and stream habitat of the river. MDC has identified 23 wingdike complexes and 10 back channel diversions along the lower Osage River channel. These navigational structures were constructed in the late 1800's and early 1900's to confine the river to a narrower, deeper river channel. These structures have trapped considerable quantities of gravel and sediment behind them and now offer a greater diversity of habitat types to the river.

Dams

Two large hydroelectric projects influence the aquatic habitat of the basin; Truman Dam and Bagnell Dam. These projects have significantly impacted stream habitat in the basin in the last 70 years. The fish faunas of the impounded reaches of these reservoirs (Table 3) has been drastically altered (Pflieger 1997). Aquatic species requiring flowing waters have been replaced by those preferring standing waters.

Impacts of these hydroelectric projects have included impoundment of streams hundreds of miles of flowing streams, bank erosion, siltation, instream flow problems, poor water quality, modified colder temperature regime, loss of riparian corridor, loss of invertebrate habitats, and reduction and/or elimination of spawning habitat. Scouring of the channel bed and banks of the lower Osage River is more apparent below Bagnell Dam than below Truman Dam. Truman Dam discharges soon meet the impounded waters of Lake of the Ozarks thereby dissipating the majority of their energy. Effects from the rapid high flow to low flow transition created by hydropower peaking operation below Bagnell Dam can be seen in streams confluencing with the Osage River below Bagnell Dam in the form of headcutting, steep eroding streambanks, and sediment deposition in stream channels. Bank stabilization procedures such as tree plantings along the Osage River have been tried but with unsatisfactory results. The unpredictability of the timing and volume of water discharged from Bagnell Dam did not allow the establishment of the tree plantings at any of the study sites (AmerenUE 1999).

The effects of the hydroelectric operations extend beyond the impounded stream reaches. Many species have had their life cycles disrupted as they can no longer ascend the river to ancestral spawning areas.

The American eel, paddlefish, sturgeon species, and walleye once ascended the Osage River but now have been denied accessed to necessary upstream habitats above Bagnell and Truman dams.

Many smaller aquatic species are dependent on periodic dispersal to maintain their populations. Populations of these species are maintained by dispersal from one tributary stream to another via larger rivers and streams. These species now occur in small isolated populations in small streams. Historically, small isolated populations of these species were occasionally eliminated by long droughts or other environmental extremes. Replenishment of these populations by upstream migration occurred before large rivers were impounded. Following impoundment, as tributary populations have been eliminated, they can not be replaced by recolonization since the reservoir acts as a dispersal barrier. The Niangua darter is one fish which has been negatively impacted by hydroelectric projects. The Niagua darter's long-term status is in jeopardy over its entire range (Pflieger 1997).

Gravel Mining

Removal of gravel from stream channels is commonly practiced in the basin and significantly degrades the quality of stream ecosystems. Instream gravel mining results in increased sedimentation rates and turbidity, shallower and larger pools downstream, and fewer downstream riffles. Gravel mining is often preceded by removal of riparian vegetation, large woody debris, and large substrate particles. According to a study by Brown and Lyttle (1992), the combined effects of gravel mining resulted in invertebrates and fish of a smaller body size at disturbed and downstream sites.

The most widespread impacts of instream gravel mining on aquatic habitats are bed degradation and sedimentation (Roell 1999). Bed degradation can be caused by pit excavation or bar skimming. Excavation of gravel in an active stream channel lowers the stream bed. This creates a nick point that locally steepens the channel slope and increases the energy locally carried by the stream. At high flows, this nick point becomes a point of bed erosion that moves upstream to form a headcut. Headcuts mobilize the sediments of the streambed sending the eroded sediment and bedload downstream. Headcut will often move considerable distances upstream into tributaries, fields, and eventually threaten bridges, ponds, and buildings. The gravel mined stream bed will incise and become wider. Characteristics of wider/shallower streams include higher temperatures, slower stream flows, less deep water habitat, and lower stream energies causing sediments that were eroded upstream to be deposited at the gravel mined site.

Deposited sediments caused by gravel mining operations can have substantial negative impacts on fish, benthic macroinvertebrates, and mussels (Brown and Lyttle 1992, Grace and Buchanan 1981). Every benthic invertebrate species is adapted to specific substrate particle sizes and bed morphology. Mayflies (*Ephemoptera*), stoneflies (*Plecoptera*), and caddisflies (*Trichoptera*) are the benthic invertebrates most readily available to foraging fishes. These groups are typically most abundant where streambed substrates are a mixture of cobbles, pebbles, and gravels. Cobble-pebble-gravel substrate mixtures are highly susceptible to alteration and encasement by deposited sediments. Once the preferred substrates are encased and covered with sediment, the benthic invertebrate species diversity, abundance, and productivity are reduced (Roell 1999). A reduction in macroinvertebrates available as fish forage in turn cause a decrease in fish numbers, diversity, and productivity. Sedimentation directly affects the ability of freshwater mussel species to feed and maintain their populations.

As discussed in the Water Quality Section, Linn Creek has undergone considerable gravel mining activity. A commercial gravel mining operation adjacent to the town of Linn Creek, Missouri mined considerable quantities of gravel from the adjacent streambed causing a 5-10 foot deep headcut to move upstream (Greg Stoner, MDC, unpublished study). The effects of this operation have been felt upstream for miles and into two tributaries and have disturbed aquatic habitat. Fortunately, a low water bridge below the gravel mining site has acted as a grade control structure which has prevented streambed lowering and degradation downstream of the site.

Riparian Corridor Assessment

Riparian corridors are defined as the stream channel and that portion of the terrestrial landscape from the high water mark towards the uplands where vegetation may be influenced by elevated water tables or flooding, and by the ability of soils to hold water (Naiman et al. 1993). Riparian corridors are some of the most biologically diverse terrestrial habitats. The riparian vegetation also has many environmental effects on stream habitat as well as the biotic community. Riparian vegetation regulates light and temperature regimes, provides nourishment to aquatic as well as terrestrial life, acts as a source of large woody debris (which significantly influences sediment routing, channel morphology and instream habitat), and regulates the flow of water and filters nutrients and pollutants from uplands to the stream. They are also the sites for chemical transformation of certain compounds.

Riparian corridor conditions of the basin were estimated by the summation of satellite image pixels adjacent to streams depicted on satellite images (Table 16). The majority of the riparian corridor is forested in all subbasins except the Little Maries River (45% forested) and the Dry Auglaize Creek (42% forested) Subbasins. The largest portion of forested riparian corridor is found in the Lower Lake of the Ozark Hills (82%) and the upper Lake of the Ozarks Hills (75%). The proportion of riparian corridor in grass cover ranged from 17% in the Lower Lake of the Ozarks Hills to 56% in Dry Auglaize Creek. Most subbasins had 1% or less of the riparian corridor currently in cropland. Exceptions included the Lower Osage River (5%), the Lower Maries River (7%), Cole Camp Creek (5%), and Miller County River hills (2%) subbasins with more of the riparian corridor in crops. Also the Osage River below Bagnell Dam averaged near 20% riparian cropland.

Stream Habitat Assessment Methods

<u>Aerial Photos</u>

In order to document the current state of the Osage River channel below Bagnell Dam, MDC took a series of aerial photos of the channel during low flow conditions during the month of August 2001. Fifty-seven points were selected (approximately 1.5 miles apart) along the channel and photographed while hovering over the channel by helicopter. A number of habitat types including riffles, runs, pools, islands, and gravel bars were observed and photographed. The lock and dam #1 at RM 12.1 as well as the gravel mining operation at Tuscumbia were also photographed. These photos will be part of an MDC archive collection. It is hoped that similar photos can be taken in the future to document any changes to the channel which are occurring from gravel mining, riparian corridor removal, water level fluctuations or excessive discharge from Bagnell Dam.

Onsite Stream Habitat Assessment

Many streams in the basin have problems with cattle access and non-existent or poor quality riparian corridors. Symptoms of excessive cattle grazing include bank erosion, poorly vegetated riparian corridors, and nutrient enrichment from cattle wastes. There are some areas with good forested streamside corridors present. These areas are often affected by lack of upstream and/or downstream corridor which create a patchy and ineffective stream corridor. The headwaters of many streams in the basin are forest or grazed pasture. Stream channels that are frequented by cattle are generally eroded.

The following observations for individual streams are based on information recorded at specific locations during fish collections in September and October 1996. Onsite stream habitat assessment were not representative of the conditions along the entire stream or subbasin. The amount of time required to sample the entire stream or subbasin in this fashion made this method of habitat description time-prohibitive. Therefore, only a few sites were described in this manner.

Onsite Stream Habitat Descriptions

Cole Camp Creek Site #1 (T42N, R21W, Sec. 2) - This reach had 45% of the stream shaded. The bank stability was good with the riparian corridor extending to the stream’s edge with some trees in the water. There were no visible signs of bank erosion except for one section of unprotected cut bank near the bridge. The bank vegetation was estimated to be 35% trees, 25% shrubs, 30% non-woody herbaceous, and 5% without vegetation. Beyond the riparian corridor, the land cover was 25% forest, 25% pasture, and 50% row crops. The width of the tree corridor on the left bank was 1-10 meters, on the right bank, the riparian corridor was 50% 1-10 meters and 50% was greater than 100 meters. All pool habitat had a depth of at least 6 ft. The site was too deep to adequately sample substrate. There were large boulders directly above the bridge and some woody debris in the stream.

Cole Camp Creek Site #2 (T42N, R21W, Sec. 28) - This reach had 20% of the stream shaded. The bank stability was poor with a large portion of vertical cut bank both at the site and below the site. A very large gravel bar with no vegetation was disturbed by gravel removal. The bank vegetation was estimated to be 20% trees, 30% shrubs, 30% non-woody vegetation, and 20% without vegetation. Beyond the riparian corridor, the land cover was 50% forest and 50% ungrazed pasture. The width of the tree corridor on the left bank was greater than 50 meters. On the right bank, the riparian corridor was greater than100 meters. There was a thin layer of silt deposited on substrate particles. The substrate composition was 10% silt, 5% sand, 20% fine gravel, 25% coarse gravel, 20% pebble, 15% cobble, and 5% boulder. Some water willow (*Justicea americana*) was observed at the site.

Cole Camp Creek Site #3 (T42N, R21W, Sec. 8) - This reach had 60% of the stream shaded. The bank stability was poor with a large portion of vertical cut bank with exposed bedrock at the base. The bank vegetation was estimated to be 35% trees, 15% shrubs, 25% non-woody vegetation, and 25% without vegetation. Beyond the riparian corridor, the land cover was 100% ungrazed pasture. The width of the tree corridor on the left bank was 50% <10 meters and 50% 25-50 meters. On the right bank, the riparian corridor was 25-50 meters. The substrate composition was 5% sand, 5% fine gravel, 10% coarse gravel, 10% pebble, 15% cobble, and 5% boulder and 50% bedrock. This site was a good mixture of riffles, runs, and pools.

Turkey Creek Site #1 (T39N, R21W, Sec. 5) - This reach had 85% of the stream shaded. Bank stability was poor with vertical cut banks about 3m high on both sides of the stream. The right bank was protected by trees and a rock bluff. The left bank has a small riparian corridor with scattered trees. Cattle have eaten or trampled most of the understory of the left bank. The bank vegetation was estimated to be 30% trees, 10% shrubs, 40% non-woody vegetation, and 20% without vegetation. Beyond the riparian corridor, the land cover was 50% forest and 50% grazed pasture. The width of the riparian corridor on the left bank was about 1-10 meters. On the right bank, the riparian corridor was over 100 meters wide. The substrate composition was 5% silt, 5% sand, 25% fine gravel, 25% coarse gravel, 35% pebble, and 5% cobble. Cattle had open access to the stream from the left bank. Habitat was simple with one long wide shallow (1 ft deep) pool with a few deep (3 ft) areas. Algae was present both at the surface and attached to the bottom. There was a small amount of simple riffle-run habitat, some woody debris, and one large (est. 70 m) gravel bar.

Turkey Creek Site #2 (T39N, R21W, Sec. 28) - This reach had 25% of the stream shaded. The bank stability was poor. The left bank has a large unprotected cut bank about 3 m high and 40 m long. The corridor has been heavily trampled by cattle on both sides of the stream. There is one stable gravel bar. The bank vegetation was estimated to be 25% trees, 5% shrubs, 40% non-woody vegetation, and 30% without vegetation. Beyond the riparian corridor, the land cover was 50% grazed forest and 50% grazed pasture. The width of the tree corridor on the left bank was about 1-10 meters. On the right bank, the riparian corridor was over 100 meters wide. The substrate composition was 5% silt, 3% sand, 10% fine gravel, 20% coarse gravel, 35% pebble, 25% cobble, and 2% bedrock. There was a small amount of aquatic vegetation (*Justicea*) but limited fish cover. There were small riffles separating pools with a small amount of woody debris. The pools were 1-5 ft deep.

Deer Creek Site # 1 (T39N, R20W, Sec. 21) - This reach had 20% of the stream shaded. The bank stability was poor. The majority of the bank was in good shape but there were some areas of cut bank. The lower left bank was protected by trees and a rock bluff. The right bank was narrow with a grazed corridor. The bank vegetation was estimated to be 30% trees, 40% shrubs, 20% non-woody vegetation, and 10% without vegetation. Beyond the riparian corridor, the land cover was 50% forest and 50% grazed pasture. The width of the tree corridor on the left bank was over 100 meters wide. On the right bank, the riparian corridor was > 10 meters wide. The substrate composition was 3% silt, 15% sand, 17% fine gravel, 10% coarse gravel, 20% pebble, 20% cobble, and 5% boulder, and 10% bedrock. There was aquatic vegetation (*Justicea*) providing some cover. There was open access to cattle on both sides of the stream with large amounts of algae on the bottom. There was a good mix of habitat types with some deep pools, some backwater habitat, and some areas fairly wide and shallow.

Deer Creek Site #2 (T40N, R20W, Sec. 19) - This reach had 45% of the stream shaded. The bank stability was good. The banks were stable on both sides with the exception of one unstable gravel bar. The bank vegetation was estimated to be 35% trees, 10% shrubs, 40% non-woody vegetation, and 15% without vegetation. Beyond the riparian corridor, the land cover was 75% forest and 25% ungrazed pasture. The width of the tree corridor on both banks was over 100 meters wide with the exception of one small area without trees. The substrate composition was 10% silt, 5% sand, 20% fine gravel, 30% coarse gravel, 30% pebble, and 5% cobble. There was aquatic vegetation (*Justicea*) and water cress in some pools providing some cover. Woody debris also provided good cover. There was a good mix of habitat types with some deep pools, some backwater habitat, and stable gravel bars.

Big Buffalo Creek (Site #1) (T41N, R19W, Sec. 7) -This reach had 55% of the stream shaded. The bank stability was poor with one long cut bank. The bank vegetation was estimated to be 15% trees, 40% shrubs, 30% non-woody vegetation, and 15% without vegetation. Beyond the riparian corridor, the land cover was 50% forest and 50% ungrazed pasture. The width of the tree corridor on the left bank was over 100 meters wide. On the right bank, the tree corridor was < 10 meters wide. The substrate composition was 10% sand, 25% fine gravel, 20% coarse gravel, 20% cobble, and 5% bedrock. This site had a good mix of riffle, run, and pool habitat.

Big Buffalo Creek (Site #2) (T41N, R20W, Sec. 23) - This reach had 65% of the stream shaded. The bank stability was poor with one long cut bank on the right side. The left bank had a large amount of unstable gravel bars. The bank vegetation was estimated to be 15% trees, 10% shrubs, 35% non-woody vegetation, and 40% without vegetation. Beyond the riparian corridor, the land cover was 100% forest. The width of the tree corridor on both banks was over 100 meters wide. The substrate composition was 3% sand, 17% fine gravel, 30% coarse gravel, 30% pebble, 15% cobble, and 5% boulder. There was no aquatic vegetation present at this site. This site had a good mix of riffle, run, and pool habitat. The maximum pool depth was more than 3 ft. There was a small amount of cover provided by root wads and cobble.

Unique Habitats

Natural Features Inventories have been completed for the basin. These inventories are ongoing efforts by M to identify and rank outstanding examples of natural communities, rare or endangered species habitat, and other significant features of interest. Several natural communities/features in the basin are listed in the MDC Natural Heritage Database. These features include: dolomite glades, caves, dry-mesic chert prairie, acid seeps, deep muck fens, dry limestone/dolomite cliffs, creeks and small rivers, mesic bottomland forests, hardpan prairies, dry chert forests, sandstone glades, large Ozark rivers, Ozark sloughs, and springs (for more information, contact the MDC Natural History Division).

Lake of the Ozarks Habitat

The upper parts of Lake of the Ozarks various arms are stream-like with a defined channel and continuous current and a fair amount of woody debris. Moving downstream, the stream characteristics are delta-like with a poorly defined stream channel and sluggish currents. These areas are typically wide and shallow, and also contain a fair amount of woody structure. Areas downstream from deltas are typical lake habitats. The majority of the banks in the area are steeply sloping and covered with coarse gravel, rock, or boulders. The depth of Lake of the Ozarks channel ranges from 8 to more than 100 feet deep. The majority of the standing timber below elevation 660' was removed prior to filling the lake. In an effort to increase woody fish habitat, many individuals as well as the Camdenton Chamber of Commerce have placed hundreds of dead trees into the lake to serve as fish habitat.

The MDC also places these woody structures at MDC accesses in an effort to provide better aquatic habitat (Stoner 2000). Additionally, trees have washed into the lake from surrounding tributaries or have fallen into the water along the shore to provide better aquatic habitat.

Instream Habitat/Bank Stabilization Projects

Tavern Creek Subbasin

There have been two stream improvement project completed on private land in the Tavern Creek Subbasin. A cedar tree revetment was installed and a 100 foot riparian corridor was planted to complete this project. This project took place on Little Tavern Creek in Maries County (Rob Pullium, MDC, personal communication).

The second of these projects took place along Tavern Creek in Miller County directly across from Brays Access. The site consisted of a 10-12 foot tall vertical actively eroding bank approximately 800-850 feet in length located on the outside of a bend on the right descending bank. Sand content in the bank soil was very high. The site contained no riparian corridor. The left bank was a large gravel bar that was in the early stages of stabilization. Many small sycamores had become established on the gravel bar. Streambank erosion was addressed by installation of a cedar tree revetment approximately 550 feet in length. Restoration of the 100 foot riparian corridor was attempted by planting 200 green ash trees. Problems ensued soon thereafter. The trees used in the revetment were too small. The sandy soil and inadequate bank coverage by the revetment led to further erosion during flood events. The willow stakes planted on the eroding bank and many of the ash trees planted in the corridor died.

Wet Glaize Creek Subbasin

Two streambank stablization projects were undertaken adjacent to Wet Glaize Creek on the Toronto Springs Conservation Area. Both involved cedar tree revetments with willow staking.

The first site was a 600 foot long bank at the downstream (northwest) end of the conservation area. About 400 feet of the bank was actively eroding. The 10 foot vertical bank was experiencing undercutting and sloughing. Large trees in the channel were aggravating the bank erosion. The second site was a 200 foot long section of bank near the middle of the area. Woody vegetation had been removed from the riparian zone and the 8 foot high vertical banks were eroding in the adjacent pasture.

At the first site, tops of trees were removed from the middle of the channel. Cedar trees were used to construct cedar revetments at both sites. Trees were planted in the riparian area at the first site. At the second site, the streambank was planted with willows during the dormant season. Hardwoods were planted to re-establish trees along the riparian corridor. The stabilization project at site one was later inspected and found to be in poor condition and not working well. The second site met with better results. The second site was found to be intact and working well.

Maries River Subbasin

There are two stream improvement projects currently underway on private land in the basin besides the previously mentioned SALT and EARTH projects. For the first project, tow rock and four hardpoints were installed to control erosion on the Maries River. There was a resulting 700 feet of stream bank protected. The corridor along the river and a drainage into the river were replanted to trees to a width of

100 feet. Additionally, this landowner plans to implement an alternative watering system for cattle, exclude cattle from the stream, remove a levee, and plant trees and warm season grasses for 1/4 mile along the stream.

Another project is being implemented along Little Maries Creek and the Maries River near Westphalia. In this project, a landowner has 400 feet of eroding streambank that was treated with 3 hardpoints. Additionally, the landowner will plant 10.1 acres of cropland to trees while reestablishing the riparian corridor to a width of 100 ft.

Upper Lake of the Ozarks Hills Subbasin

The MDC has completed several studies on the Big Buffalo Creek Conservation Area which involved stream habitat improvement. MDC purchased this area in 1963. During the 1940's, a section of Big Buffalo Creek was channelized together with a section of Pole Hollow Creek. The combined creeks were directed into one 0.8 mile long nearly straight channel. This was the result of attempts by the previous landowner to speed up the movement of flood flows through the property and thus minimize flooding of low lying cropland. The straightening of the stream resulted in a poorly defined, unstable, shallow channel practically devoid of fish cover. MDC planned to dechannelize this stream and sampled the fish community before restoration efforts were undertaken. In 1965, MDC separated the two channels totaling 1.8 miles in length. This was similar to the lengths of the streams prior to channelization. Also, log, rock, and gabion structures were installed to stop bank erosion and provide fish cover. It was determined that restoration efforts were successful and that fish populations did increase along the restored streams (Fajen 1975).

The MDC manages the aquatic habitat of the Saline Valley Conservation Area. During the period from 1983-1986, MDC attempted to alter the stream flow of Saline Creek on the Saline Valley Conservation Area using earthen berms. The purpose of the berm construction was to increase the sinuosity of the stream channel. Instream habitat improvement structures were also installed on Little Saline Creek to create deep pool habitat. More recently, management efforts on the area have focused on stabilizing stream erosion sites and reestablishing woody riparian corridors to a width of 200 ft along 3rd order and larger portions of the Osage River, Saline Creek, Little Saline Creek, Jack Buster Creek, and Jim Henry Creek within the area boundaries. Efforts are also underway to establish a similar corridor of 100 ft on 1st and 2nd order streams of the area.

Table 3. Total county populations and estimated changes for Missouri counties that include portions of the East Osage River Basin.

County	1990 Pop.	1995 Pop.	2000 Est.	2005 Est.	2010 Est.	2015 Est.	2020 Est.
Benton	13,859	14,705	15,421	15,992	16,404	16,621	16,629
Camden	27,495	30,950	34,061	36,838	39,135	40,872	41,978
Cole	63,579	66,418	68,761	70,803	72,645	74,244	75,515
Hickory	7,335	7,758	8,103	8,345	8,475	8,499	8,429
Laclede	27,158	28,524	29,834	31,124	32,373	33,593	34,700
Maries	7,976	8,183	8,389	8,587	8,788	8,975	9,122
Miller	20,700	21,710	22,730	23,812	24,897	25,916	26,860
Morgan	15,574	16,433	17,197	17,883	18,456	18,883	19,145
Osage	12,018	11,979	11,929	11,912	11,914	11,923	11,920
Pulaski	41,307	43,816	46,322	48,994	51,836	54,742	57,634
Total	237,001	250,476	262,747	276,295	286,933	296,283	303,952

Source: Missouri State Office of Administration (1998).